

AD-A031 155

EDGEWOOD ARSENAL ABERDEEN PROVING GROUND MD  
A DIRECT METHOD FOR THE DETERMINATION OF PHENOL IN NATURAL WATE--ETC(U)  
OCT 76 L M MCCORMACK, A GOODMAN, A R JONES

F/G 13/2

UNCLASSIFIED

ED-TR-76048

NL

| OF |

AD  
A031155

END

DATE  
FILMED

11-76

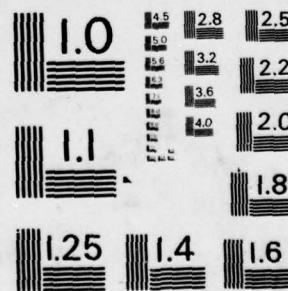
THIS REPORT WAS BEEN DELIVERED  
AND CLEARED FOR PUBLIC RELEASE  
UNDER THE EXECUTIVE ORDER AND  
NO RESTRICTIONS ARE IMPOSED UPON  
ITS USE AND DISSEMINATION.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE  
DISTRIBUTION UNLIMITED.

1 OF

AD  
A03/15



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS - 1963 - A

AD A031155

AD

EDGEWOOD ARSENAL TECHNICAL REPORT

ED-TR-76048

A DIRECT METHOD FOR THE DETERMINATION  
OF PHENOL IN NATURAL WATERS

by

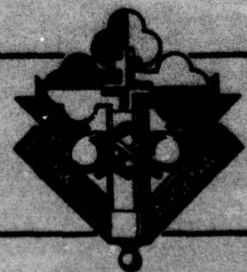
Lawrence M. McCormack  
Alan Goodman  
Arthur R. Jones  
Achille Silvestri

Development and Engineering Directorate

October 1976



DEPARTMENT OF THE ARMY  
Headquarters, Edgewood Arsenal  
Aberdeen Proving Ground, Maryland 21010



Approved for public release; distribution unlimited.

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Disposition

Destroy this report when no longer needed. Do not return it to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER ED-TR-76048	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) A DIRECT METHOD FOR THE DETERMINATION OF PHENOL IN NATURAL WATERS		5. TYPE OF REPORT & PERIOD COVERED Technical Report, JUN-Oct 74, June 1974 to October 1974	
7. AUTHOR(s) Lawrence M. McCormack, ↓ Arthur R. Jones Alan Goodman, Archille Silvestri		6. PERFORMING ORG. REPORT NUMBER	
8. PERFORMING ORGANIZATION NAME AND ADDRESS Commander, Edgewood Arsenal Attn: SAREA-DE-D Aberdeen Proving Ground, Maryland 21010		8. CONTRACT OR GRANT NUMBER(s)	
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, Edgewood Arsenal Attn: SAREA-TS-R Aberdeen Proving Ground, Maryland 21010		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS EPA-1AG 0546	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE October 1976	
		13. NUMBER OF PAGES 21	
		15. SECURITY CLASS. (of this report) UNCLASSIFIED	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA	
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited. Copies available from: National Technical Information Service, Springfield, Virginia 22151.			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Phenol                                      Linear range Natural waters                              Industrial pollutants Berthelot reaction                              Sodium nitroprusside			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  Present methods for the determination of phenols in water require a two-step procedure: separation of phenol by steam distillation or extraction with solvent; determination of phenol colorimetrically. The need to find a simple analytical method applicable to field situations led to the investigation of the Berthelot reaction. It was found that:  1. Phenol is detectable to 1 µg/ml in water solutions using a modification of the Berthelot reaction. (continued on reverse side)			

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

401007

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. ABSTRACT (contd)

2. Linearity of the method is good from 1 to 5  $\mu\text{g/ml}$  of phenol, with a range of up to 15  $\mu\text{g/ml}$  with some loss of linearity.
3. When tested against 33 potential pollutants, the method showed good specificity for phenols.
4. This method is adequate for laboratory determination of phenol; however, the requirements for addition of several reagents and heating makes field use impractical.

Accession for	Write Section	<input checked="" type="checkbox"/>
NTIS	Ref Section	<input type="checkbox"/>
DOC		
UNANNOUNCED		
JUSTIFICATION		
BY	DISTRIBUTION/AVAILABILITY CODES	
Dist.	AVAIL. AND OF	SPECIAL
A		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

## PREFACE

The work described in this technical report was authorized under an agreement with the Environmental Protection Agency, EPA-1AG 0546, 2 May 1974. This work was started in June 1974 and completed in October 1974. Experimental data are recorded in notebooks 9169 and 8685.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Reproduction of this document in whole or in part is prohibited except with permission of the Commander, Edgewood Arsenal, Attn: SAREA-TS-R, Aberdeen Proving Ground, Maryland 21010; however, DDC and the National Technical Information Service are authorized to reproduce the document for United States Government purposes.

### SUMMARY

↙ A rapid, direct procedure for the determination of phenol, sensitive in the microgram range, has been devised utilizing a modification of the Berthelot reaction. The method is especially applicable to water samples and requires no extraction or distillation. Phenol, as the limiting factor, produces a strong indophenol blue color, which is linear in the range of 1 to 5  $\mu\text{g/ml}$ . Challenge of the method with 33 potential water pollutants shows good specificity for phenols. ↘

## CONTENTS

	<u>Page</u>
I. INTRODUCTION . . . . .	9
II. EXPERIMENTATION . . . . .	9
III. RESULTS AND DISCUSSIONS . . . . .	11
IV. CONCLUSIONS . . . . .	13
LITERATURE CITED . . . . .	15
APPENDIX, HAZARDOUS MATERIALS . . . . .	17
DISTRIBUTION LIST . . . . .	19

# A DIRECT METHOD FOR THE DETERMINATION OF PHENOL IN NATURAL WATERS

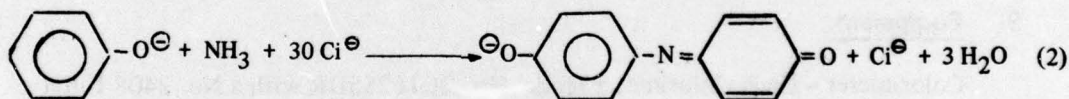
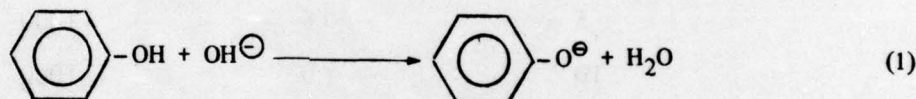
## I. INTRODUCTION.

Present methods for the determination of phenols in water require a two-step procedure:

1. Separation of the phenol from the solution by steam distillation<sup>1,3</sup> or extraction with solvent.<sup>2</sup>
2. Determination of phenol is then accomplished colorimetrically by reaction with 4-aminoantipyrine<sup>1</sup> or 3-methyl-2-benzathiazolinone.<sup>3</sup> Analysis can also be accomplished by various elaborate instrumental methods,<sup>4</sup> as was reviewed by Minear and Pagoria.<sup>5</sup>

The requirement for a simple analytical method applicable to field situations, involving spills of toxic materials in waterways, led to the investigation of the Berthelot reaction.<sup>6</sup> This well-known method is used for determining blood urea nitrogen in serum,<sup>7,8</sup> for the direct estimation of ammonia in biological fluids,<sup>9</sup> and, more recently, for the determination of ammonia in natural water.<sup>10,11</sup>

The classical Berthelot reaction utilizes phenol, ammonia, and alkaline hypochlorite to form indophenol blue in the presence of a suitable catalyst:



## II. EXPERIMENTATION.

Analytical grade chemicals were used for all of the following preparations:

### A. Reagents.

#### 1. NaOCl/NaOH.

Add 10 ml of commercial bleach (5% NaOCl) to 60 ml of 10% aqueous NaOH and dilute to 1 liter with distilled water.

#### 2. Ammonia Reagent.

Dilute 10 ml of concentrated ammonium hydroxide to 100 ml with distilled water.

3. Sodium Nitroprusside.

a. Stock Solution.

Dissolve 6.0 grams of sodium nitroprusside in 100 ml distilled water.

b. Working Solution.

Dilute 12.5 ml of stock solution to 500 ml with distilled water.

4. Phenol Standards.

a. Stock Solution (10 mg/ml Phenol).

Place 5.0 grams of melted phenol in a 500-ml volumetric flask and dilute to volume.

b. Working Standards.

<u>Concentrated phenol</u>	<u>Stock</u>	<u>Final volume</u>
<u>µg/ml</u>	<u>ml</u>	<u>ml</u>
1	0.1	1000
5	0.5	1000
10	1.0	1000
15	1.5	1000

B. Equipment.

Colorimeter - Hach Colorimeter Model No. DC16255DR with a No. 2408 Filter  
Hach Chemical Company, Ames, IA 50010

C. Procedure.

1. In a 25-ml graduated glass-stoppered cylinder place:

	<u>Distilled water</u>	<u>Phenol standard</u>	<u>Caustic/bleach</u>	<u>NH<sub>3</sub> reagent</u>	<u>Catalyst</u>
	<u>ml</u>	<u>ml</u>	<u>ml</u>	<u>ml</u>	<u>ml</u>
Blank	21.0	—	2.0	1.0	1.0
Test	—	21.0	2.0	1.0	1.0

2. Incubate both blank and test in water bath for 5 minutes at  $56^{\circ} \pm 2^{\circ}\text{C}$ .

3. Cool at room temperature for 5 minutes. Read in colorimeter, setting zero absorbance with blank solution.

### III. RESULTS AND DISCUSSION.

After determining, qualitatively, that the reaction did proceed as theorized, a series of studies was carried out to optimize the procedure and determine its linearity.

#### A. Effect of Catalyst Concentration.

Working concentrations of sodium nitroprusside were prepared and utilized in the procedure described. The results shown in table 1 indicate that acceptable absorbance ranges are attained with a catalyst concentration of 60  $\mu\text{g/ml}$  in the final reaction mixture. Above this level, the deep yellow color produced interfered with the zeroing of the colorimeter, as was found by Chaney and Marbach.<sup>8</sup>

Table 1. Effect of Sodium Nitroprusside Catalyst Concentration on the Reaction Rate

Phenol $\mu\text{g/ml}$	Catalyst concentration of final reaction mixture $\mu\text{g/ml}$		
	16	32	60
	Absorbance		
1	0.050	0.098	0.135
5	0.280	0.450	0.690
10	0.435	0.720	1.150

#### B. Effect of Temperature.

Holding other parameters constant, standard curves were prepared (as shown in table 2) at reaction temperatures of 30°, 40°, and 56°C for 10 minutes. Table 2 shows that at 56°C a maximum absorbance was attained. Although temperatures higher than those recorded here were tried, unreliable results were obtained. The results show a rapid attainment of maximum color development at 56°C; and it was also noted that upon standing the samples processed at lower temperatures approached but did not attain the absorbance of those prepared at 56°C. This temperature was also used by several workers<sup>8,9</sup> with consistent results.

Table 2. Effect of Temperature on the Reaction Rate

Phenol $\mu\text{g/ml}$	Temperature, °C $\pm 2$		
	30°C	40°C	56°C
	Absorbance		
1	0.015	0.088	0.135
5	0.078	0.310	0.680
10	0.082	0.620	1.150

C. Effect of Time.

Standard curves were prepared, as described above, with incubation times of 5 and 10 minutes. The curves that these data produced showed no significant differences; thus the 5-minute time of incubation was adopted.

D. Linearity.

A standard curve was prepared over a working range of phenol (table 3, 1). Due to the high absorbance readings above 1.0, a further curve was constructed (table 3, 2) which showed good linearity in the range of 1 to 5  $\mu\text{g/ml}$ , and this was determined to be the most useful operating range for this method.

Table 3. Phenol Standard Curves

1.	Phenol $\mu\text{g/ml}$	Absorbance
	1	0.168
	5	0.700
	10	1.180
	15	1.420
2.	Phenol $\mu\text{g/ml}$	Absorbance
	1	0.150
	3	0.400
	5	0.660

E. Specificity.

The method was challenged with 33 potential industrial pollutants (listed in the appendix) to:

1. Test the specificity of the method
2. Gain some appreciation of the method's usefulness as a field test. To accomplish the latter, the following procedural changes were made:
  - a. The reagent blank was deleted - the colorimeter was therefore set against distilled water, thus simplifying the procedure since the absorbance of the reagent blank is consistently low.

b. Heating was done with a small portable field stove fired by a concentrated fuel tablet.

Utilizing the modifications, it was found that only four potential pollutants showed any response (table 4). Phenol and nonylphenol reacted as was expected. Also reacting were benzene, probably containing phenol as a contaminant, and technical grade Sevin, a pesticide which contains naphthol from either the hydrolysis of Sevin itself or from its synthesis.

Table 4. Specificity of Response

Compound	$\mu\text{g/ml}$	Absorbance
Phenol	1	0.162
	10	1.100
	100	1.580
	1000	1.800
Nonylphenol	1.7	0.100
	17	0.296
Benzene	1000	0.088
Sevin	4	0.162
	40	0.202

#### IV. CONCLUSIONS.

1. Phenol is detectable to  $1 \mu\text{g/ml}$  in water solutions using a modification of the Berthelot reaction.
2. Linearity of the method is good from 1 to  $5 \mu\text{g/ml}$  of phenol, with a range of up to  $15 \mu\text{g/ml}$  with some loss of linearity.
3. When tested against 33 potential pollutants, the method showed good specificity for phenols.
4. This method is adequate for laboratory determination of phenol; however, the requirements for addition of several reagents and heating makes field use impractical.

### LITERATURE CITED

1. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Standard Methods for Examination of Water and Waste Water. 13th Edition, February 1971.
2. Cooper, R. L., and Wheatstone, K. C. The Determination of Phenols in Aqueous Effluents. *Water Research* 7, 1375-1384 (1973).
3. Goulder, P. D., Brookshank, P., and Day, M. B. Determination of Submicrogram Levels of Phenol in Water. *Anal. Chem.* 45 (14), 2430-2433 (1973).
4. Bhatia, Kishan. Determination of Trace Phenol in Aqueous Solution by Aqueous Chromatography. *Anal. Chem.* 45 (8), 1344-1347 (1973).
5. Minear, Roger, and Pagoria, P. S. Organics. *J. Water Pollution Control Federation* 46 (6), 1058-1100 (1974).
6. Berthelot, M. *Repertoire de Chemic Applique* 1, 284 (1859).
7. Searcy, R. L., Gaugh, G. S., Korotger, J. J., and Berquist, L. M. Evaluation of a New Technique for Estimation of Urea Nitrogen in Serum. *Am. J. Med. Tech.* 27, 255-262 (1961).
8. Chaney, A. L., and Marbach, C. P. Modified Reagents for Determination of Urea and Ammonia. *Clinical Chemistry* 8 (2), 130-132 (1962).
9. Waterburn, M. W. Phenol-Hypochlorite Reaction for Determination of Ammonia. *Anal. Chem.* 39 (8), 971-974 (1967).
10. Harwood, J. E., and Kuhm, A. L. A Colorimetric Method for Ammonia in Natural Waters. *Water Research* 4, 805-811 (1970).
11. Solorzano, Lucia. Determination of Ammonia in Natural Waters by the Phenol-Hypochlorite Methol. *Limnology and Oceanography* 14, 799-801 (1969).

## APPENDIX

### HAZARDOUS MATERIALS

1. Phenol
2. Methyl alcohol
3. Acrylonitrile
4. Chlorosulfonic acid
5. Benzene
6. Ammonium chloride
7. Phosphorous pentasulfide
8. Styrene
9. Acetone cyanohydrin
10. Calcium hypochlorite
11. Nonylphenol
12. Isoprene
13. Xylenes
14. Nitrophenol
15. Ammonium nitrate
16. Aluminum sulfate
17. Aldrin
18. Toxaphene
19. DDT
20. EPN
21. Malathion
22. Parathion
23. Dieldrin
24. Heptachlor
25. Sevin
26. Chlordane
27. Fermate
28. Lead arsenate
29. Disodium methylarsenate
30. Phenylmercuric chloride
31. 2,4-D (Acid)
32. 2,4,5-T (Acid)
33. Ammonium phosphate, dibasic

# DISTRIBUTION LIST 21

Names	Copies	Names	Copies
EDGEWOOD ARSENAL		US Army Research and Standardization Group (Europe)	1
TECHNICAL DIRECTOR		Box 65, FPO New York 09510	
Attn: SAREA-TD-E	1	OFFICE OF THE SURGEON GENERAL	
Attn: SAREA-TD-P	1	HQDA (SGRD-EDF)	
FOREIGN INTELLIGENCE OFFICER	1	Attn: LTC Charles Dettor	1
CHIEF, LEGAL OFFICE	1	WASH DC 20314	
CHIEF, SAFETY OFFICE	1	Commander	
CDR, US ARMY TECHNICAL ESCORT CENTER	1	US Army Medical Bioengineering Research & Development Laboratory	
PUBLIC HEALTH SERVICE LO	8	Attn: SGRD-UBG	1
AUTHOR'S COPY, Development and Engineering Dir	4	Attn: SGRD-UBD-AL	1
BIOMEDICAL LABORATORY		Fort Detrick, Bldg 568 Frederick, MD 21701	
Attn: SAREA-BL-M	1	US ARMY HEALTH SERVICE COMMAND	
Attn: SAREA-BL-R	1	Commander	
Attn: SAREA-BL-V	1	US Army Environmental Hygiene Agency Attn: USAEHA-AL, Librarian, Bldg 2100	1
CHEMICAL LABORATORY		APG-Edgewood Area	
Attn: CL-C	1	Commander	1
Attn: SAREA-CL-D	1	US Army Institute of Surgical Research Brooke Army Medical Center Fort Sam Houston, TX 78234	
Attn: SAREA-CL-T	1	Superintendent	
Attn: SAREA-CL-TE	1	Academy of Health Sciences	
DEVELOPMENT AND ENGINEERING DIRECTORATE		US Army	
Attn: SAREA-DE-S	1	Attn: HSA-CDC	1
MANUFACTURING TECHNOLOGY DIRECTORATE		Attn: HSA-RHE	1
Attn: SAREA-MT-E	1	Fort Sam Houston, TX 78234	1
DIRECTOR OF PRODUCT ASSURANCE	1	US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND	
Attn: SAREA-PA-A	1	Commander	
Attn: SAREA-PA-P	1	US Army Materiel Development and Readiness Command	
Attn: SAREA-PA-Q	1	Attn: DRCDE-EA	1
DIRECTOR OF TECHNICAL SUPPORT		Attn: DRCDE-R/Dr. D. Stefanye	1
Attn: SAREA-TS-R	2	Attn: DRCDE-WB	1
Attn: SAREA-TS-L	3	Attn: DRCIS-MD	1
Attn: SAREA-TS-E	1	Attn: DRCDL	1
DEPARTMENT OF DEFENSE		Attn: DRCPA-E	1
Administrator		Attn: DRCMM-S	1
Defense Documentation Center		5001 Eisenhower Ave Alexandria, VA 22333	
Attn: Accessions Division	12	Commander	
Cameron Station		US Army Foreign Science & Technology Center	
Alexandria, VA 22314		Attn: DRXST-IS1	2
Director		220 Seventh St., NE Charlottesville, VA 22901	
Defense Intelligence Agency			
Attn: DIR-4G1	1		
Washington, DC 20301			
DEPARTMENT OF THE ARMY			
HQDA (DAMO-ODC)	1		
WASH DC 20310			
Director			
Defense Civil Preparedness Agency			
Attn: PO(DC)	1		
Washington, DC 20301			

# DISTRIBUTION LIST NO. 21 (Contd)

Names	Copies	Names	Copies
Commander USDRC STIT-EUR APO New York 09710	1	Commander Frankford Arsenal Attn: SARFA-MTT-C Philadelphia, PA 19137	1
Redstone Scientific Information Center Attn: Chief, Documents US Army Missile Command Redstone Arsenal, AL 35809	2	Commander Picatinny Arsenal Attn: SARPA-MT-F Attn: SARPA-IS-FE Dover, NJ 07801	1 1
Commander US Army Science & Technology Center-Far East Office APO San Francisco 96328	1	US ARMY TRAINING & DOCTRINE COMMAND  Commandant US Army Missile & Munitions Center & School Attn: ATSK-TEB-E Redstone Arsenal, AL 35809	  1
Project Manager for Chemical Demilitarization and Installation Restoration Attn: DRXDC APG-Edgewood Area	1	Commander HQ, USATRADOC Attn: ATEN-ME Fort Monroe, VA 23651	1
Commander US Army Materiel Development and Readiness Command Installations and Services Agency Attn: DRCIS-RI-IU Rock Island, IL 61202	1	US ARMY TEST & EVALUATION COMMAND  Record Copy CDR, APG Attn: STEAP-AD-R/RHA APG-Edgewood Area, Bldg E5179	  1
US ARMY ARMAMENT COMMAND  Commander US Army Armament Command Attn: DRSAR-ASH Attn: DRSAR-ASF Attn: DRSAR-ISE Attn: DRSAR-PPI Attn: DRSAR-RD Attn: DRSAR-RDT Attn: DRSAR-SC Rock Island, IL 61201	  1 1 1 1 1 1 1	CDR, APG Attn: STEAP-TL APG-Aberdeen Area  Commander Tooele Army Depot Attn: AMXTE-CAMDS Tooele, UT 84074	  1   1
Commander Rocky Mountain Arsenal Attn: SARRM-EA Attn: SARRM-MD Denver, CO 80240	  1 1	Commander US Army Test & Evaluation Command Attn: AMSTE-NB APG-Aberdeen Area	  1
Commander Pine Bluff Arsenal Attn: SARPB-ETA Pine Bluff, AR 71611	1	Commander US Army Arctic Test Center Attn: STEAC-MT-EB APO Seattle 98733	1
Commander Frankford Arsenal Attn: Library Branch, TSP-L Bldg 51-2 Philadelphia, PA 19137	1	Commander US Army Tropic Test Center Attn: STETC-MO-A (Tech Library) APO New York 09827	1
		Commander Dugway Proving Ground Attn: STEDP-PC Dugway, UT 84022	4

DISTRIBUTION LIST NO. 21 (Contd)

Names	Copies	Names	Copies
<b>DEPARTMENT OF THE NAVY</b>		<b>DEPARTMENT OF THE AIR FORCE</b>	
Chief of Naval Research Attn: Code 443 800 N. Quincy Street Arlington, VA 22209	1	HQ Foreign Technology Division (AFSC) Attn: PDTR-3 Wright-Patterson AFB, OH 45433	1
Commander Naval Facilities Engineering Command Attn: Code 032E 200 Stovall Street Alexandria, VA 22332	1	HQ, USAF/SGPR Forrestal Bldg WASH DC 20314	1
Commander Naval Surface Weapons Center White Oak Laboratory Silver Spring, MD 20910	1	HQ, Ogden ALC/MMNTM Hill AFB, UT 84406	1
Commander Naval Intelligence Support Center 4301 Suitland Road Washington, DC 20390	1	Director Air Force Inspection and Safety Center Attn: IGD(AFISC/SEV) Norton AFB, CA 92409	1
Commander Naval Ordnance Systems Command Attn: ORD-03D Washington, DC 20360	1	Commander Armament Development & Test Center Attn: DLOSL (Technical Library) Eglin AFB, FL 32542	1
Commander Naval Surface Weapons Center Dahlgren Laboratory Attn: GFC Dahlgren, VA 22448	1	HQ, NORAD/DOCUN Ent AFB, CO 80912	1
Chief, Bureau of Medicine & Surgery Department of the Navy Attn: CODE 553-1 Washington, DC 20372	1	<b>OUTSIDE AGENCIES</b>	
Commander Naval Air Systems Command Attn: Code AIR-350E Attn: Code AIR-53231B Washington, DC 20361	1	Director of Toxicology National Research Council 2101 Constitution Ave, NW Washington, DC 20418	1
Commander Naval Weapons Center Attn: Technical Library/Code 533 China Lake, CA 93555	1	Director Central Intelligence Agency Attn: ORD/DD/S&T Washington, DC 20505	1
Commanding Officer Naval Weapons Support Center Attn: Code 5042/Dr. B. E. Douda Crane, IN 47522	1		